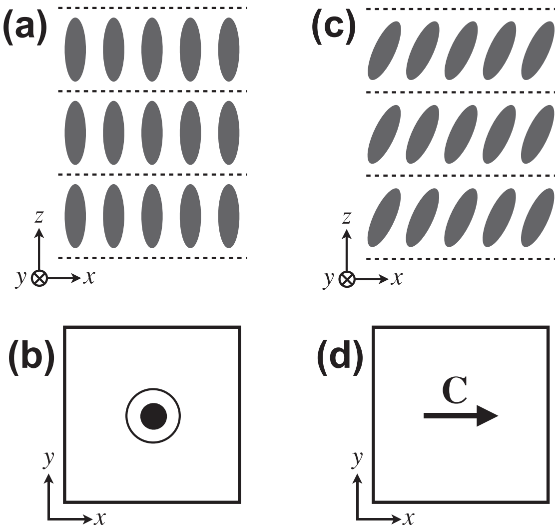

Fig. 1. Smectic liquid crystal. The broken lines show layer structures. (a), (b) Smectic A phase. (c), (d) Smectic C phase.

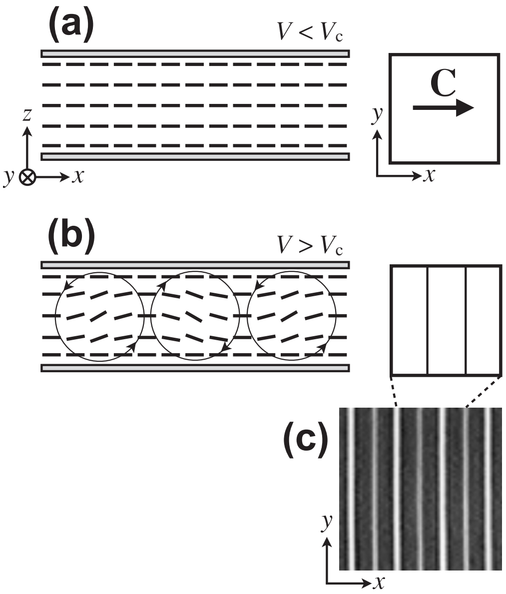

Fig. 2. Planar alignment system of a nematic liquid crystal. (a) Initial state. (b) Electroconvective state. (c) Convective pattern observed under a polarizing microscope.

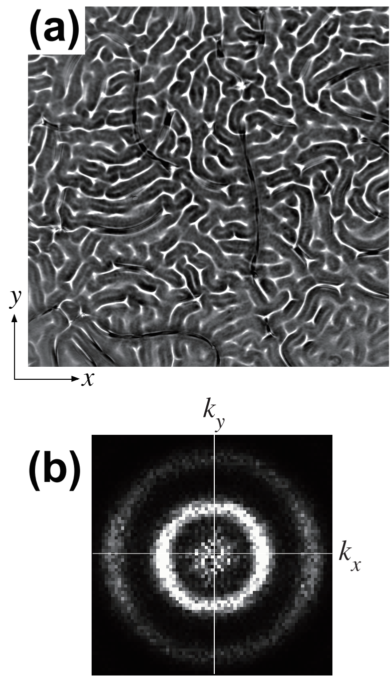

Fig. 3. (a) Pattern of the soft-mode turbulence. (b) Two-dimensional spectrum of (a).

and explained by the Carr-Helfrich effect (de Gennes and Prost, 1993). The electroconvection in nematic liquid crystals has been supplied rich variety of subjects of nonlinear dynamics because it has many advantages for experimental and theoretical researches comparing to conventional fluid systems, e.g., Rayleigh-Bénard convection systems. Now, let's describe briefly how to set our sample. A nematic liquid crystal is sandwiched between two electrodes and the direction of the molecules (the director) is aligned parallel to the electrodes. By a surface treatment of the electrodes, e.g., polymer coating and rubbing procedure along the x-direction, the directors can be aligned to one direction. This surface treatment artificially breaks the continuous rotational symmetry in the electrode plane, such as the x–y direction, that is, the x and y directions have not equal property each other. This system is called the planar alignment. The direction of the convective rolls due to the electrohydrodynamic instability here is perpendicular to the initial alignment of the directors (Fig. 2). Therefore, the wavevector $\mathbf{q}$ of the stripe pattern becomes uniformly parallel to the x-direction. In electroconvection of nematic liquid crystals, generally convective flow leads an anisotropic torque on the $\mathbf{C}$ because of the viscous anisotropy. In the planar system, since the rotation of the $\mathbf{C}$ by the viscous torque is suppressed by the initial breaking of the rotational symmetry due to the rubbing, the $\mathbf{C}(\mathbf{r})$ and the convective stripe pattern can be stable at primary state above V_c.

If the directors are aligned perpendicular to the electrodes, what happens now? This state traditionally called the homeotropic alignment (HA) in the liquid crystal fields. HA becomes unstable for an electric field beyond a threshold voltage V_F, the Fréedericksz transition point (de Gennes and Prost, 1993), at which the directors tilt against the electrode. In some sense, this aspect has a good analogy to the transition from smectic A to C phase though their intrinsic physics is different. Then the continuous rotational symmetry in the the x–y plane is spontaneously broken, since the tilt direction is arbitrary as previously described. Consequently, the fluctuation of the azimuthal angle ϕ of the $\mathbf{C}$ can be regarded as a NG mode similar to that in the smectic C phase (note, we are talking about only one layer of smectic C as an anology). Further increasing the control parameter, electroconvection occurs at a secondary threshold voltage V_c. Now note also that this state is dissipative while Fréedericksz state is not. In this system, two NG modes which originate respectively from the rotational and the translational symmetries coexist. In other words, a short-wavelength mode of electroconvection coexists with the NG mode of ϕ. In the homeotropic system, the rotation